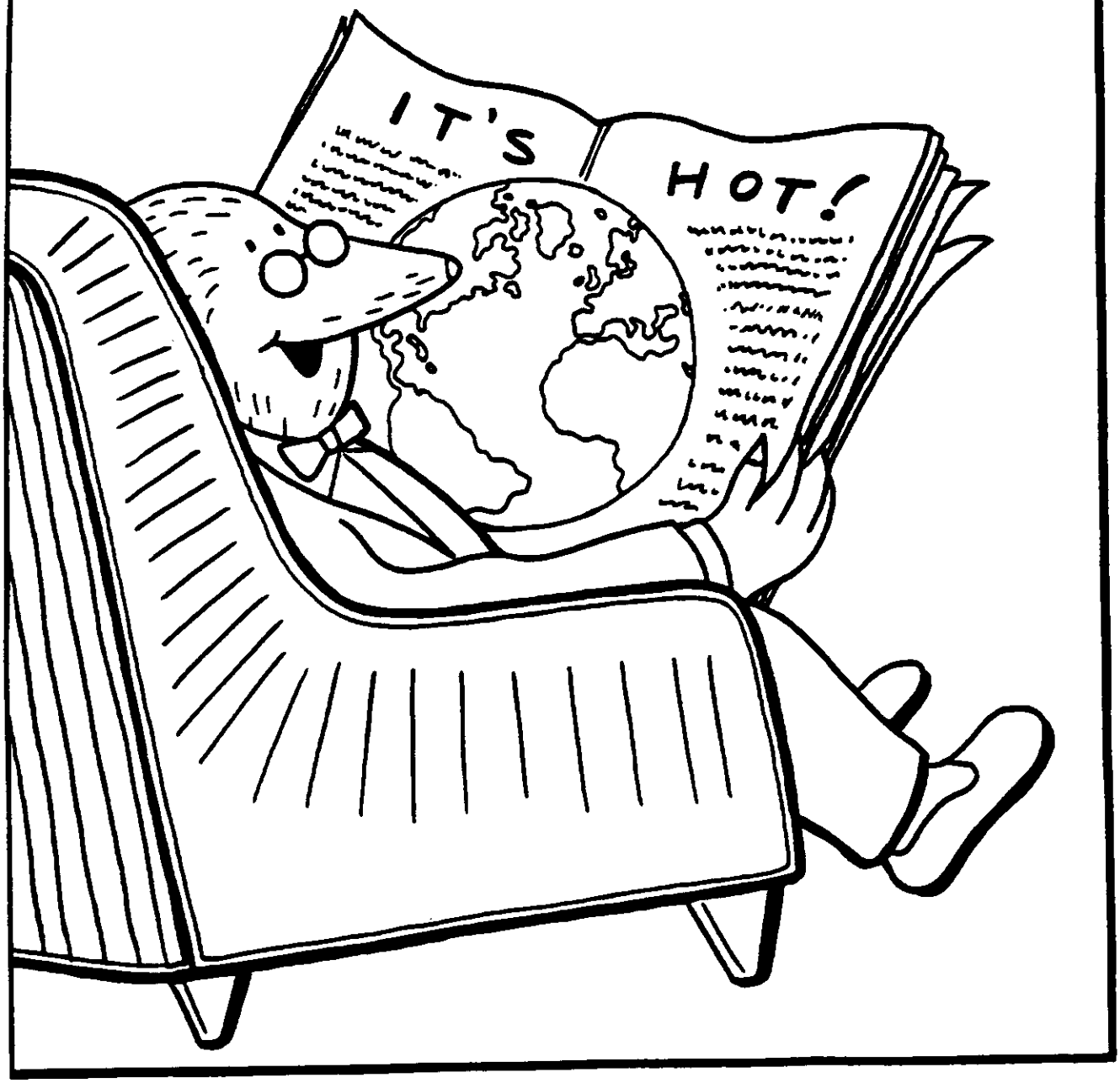
A GEOTHERMAL SCRAPBOOK: HOT ITEMS

SECTION V



Another Hot Resource

Earth Heat

Many know about hot springs, geysers and volcanoes — all evidence of the tremendous heat that lies within the earth. However, many don't know that there is another not-so-dramatic heat energy resource — earth heat. With its huge mass and insulating properties, the earth maintains a constant temperature just a few feet below the surface. We can take advantage of these stable temperatures by installing a simple system called a geothermal – or "ground source" – heat pump. Even where other forms of geothermal energy aren't readily available, geothermal heat pumps (GHP's) can be used to heat homes and buildings.

Used all over northern Europe for many years, GHP's are a relatively new technology in the United States – in commercial use only since about 1980. Like other types of heat pumps (such as "air-source" and "water-source") *GHP's **move** heat **instead of making** heat.*

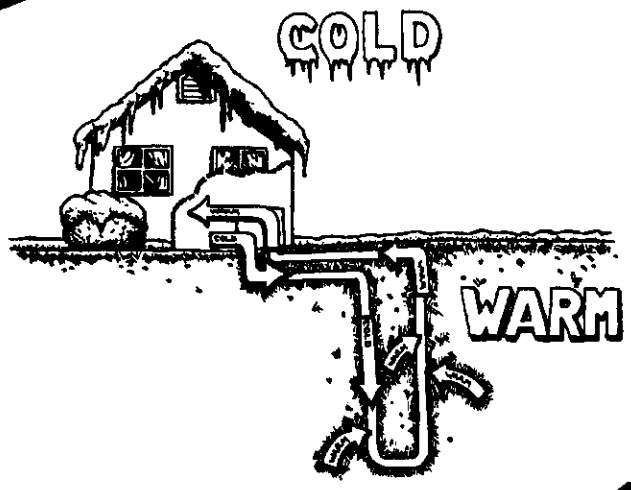
Starting at just about four feet below the surface, the earth's temperature is around 52 degrees Fahrenheit. In order to make use of this constant temperature, water is circulated through many yards of looped pipe, installed (either vertically or horizontally) underground. If a building is being *heated*, the water circulating in the pipe absorbs heat from the earth (due to heat flow). This "captured" earth heat is then "boosted" to a higher temperature, using a heat exchanger. Then the heat is circulated through the building.

By reversing the action of the heat exchanger, earth heat can be used to cool buildings, too. To *cool* a building, the heat pump shifts heat *out* of it. The water circulating in the pipes is warmed by hot summer air, then carried underground where the heat from it flows into the earth, and the same water, *now cooler*, returns to the building, where it captures more heat and takes it away.

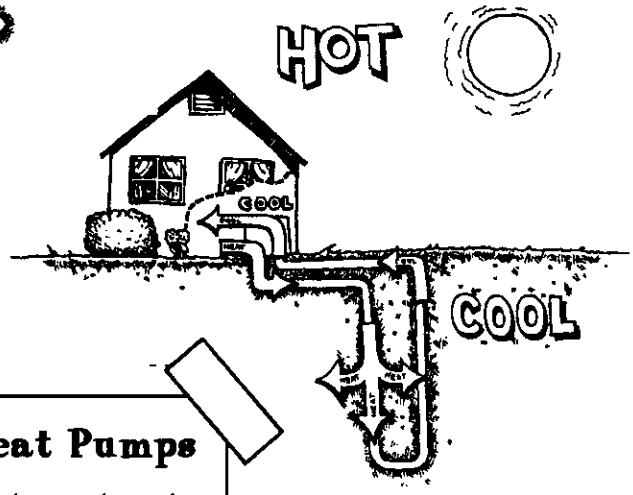
Because GHP's don't generate much pollution (they do use a little electricity to move the heat around) and are very energy efficient, they are on the list of preferred technologies selected by the Environmental Protection Agency.

The United States Department of Energy, the EPA, the Geothermal Resources Council, the Geo-Heat Center and others are all looking very closely at GHP's as an important new technology for helping to meet the energy needs of today and tomorrow. How about you?

HOT RESOURCES



Heat pumps (GHPS's) take heat *from* the earth in winter and bring it into homes, schools and businesses. In the summer they take heat away from these buildings and move it *into* the earth.



Graphics courtesy of Oklahoma State University

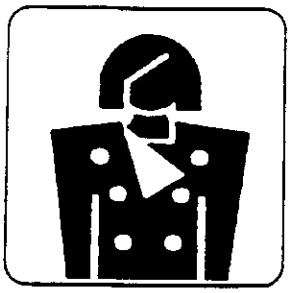
Advantages of Heat Pumps

- Though initial costs are higher than traditional systems, consumers can save from $200-$800 per year or more (depending on home size) on energy bills, thus recovering their investment and saving a great deal of money on future energy costs.
- Because of their high efficiency, GHP's save large amounts of electricity and natural gas when compared to other heating/cooling systems.
- Their simple design makes the maintenance of GHP's easier than traditional systems.
- Because the loops are underground, outdoor landscape is rarely affected.
- Local contractors can do most of the work, so the GHP business is attractive for local economies.
- It has been estimated that over one-half of the United States has places suitable for GHP installation.

HOT CAREERS

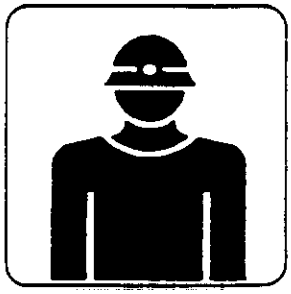
Is There a Job For You in Geothermal?

People like to work in the geothermal industry. It gives them satisfaction to produce heat and electricity which improve people's lives without hurting the earth and the air. The search for geothermal resources and the development of geothermal energy is challenging and open to innovation.



Geologists search for geothermal heat near the earth's surface. Geochemists, geophysicists, hydrologists and other specialists help in the search. If a geothermal reservoir is found, then land ownership permitting and leasing specialists obtain rights for exploration and development. Project managers and drilling engineers work with geologists to plan a drilling program to find the resource.

A successful well requires the cooperation of many special workers — tool pushers, mud loggers, pipefitters, cement truckers and water truckers. If the temperature of the resource is low, fish farmers and greenhouse growers use it to grow fish, vegetables or flowers. Architects, builders and heating experts plan and construct houses and commercial buildings heated by low-temperature geothermal waters. If the temperature is high enough to make electricity, then other workers are needed.



Geologists and reservoir engineers plan where to drill for steam and hot water. Electrical and mechanical engineers and construction workers design and build power plants to turn steam into electricity. City planners and power line operators work with utilities and governments to plan how to move the electricity to people.

Before the power plant and power lines are constructed, expert wildlife biologists, botanists, soil scientists, archaeologists, hydrologists, air quality scientists, chemists, engineers, and noise specialists prepare environmental impact studies which are needed to safeguard nature during development. Power plant operators, financial experts, accountants and bookkeepers, corporate attorneys, public relations professionals, government regulatory experts, administrative assistants, and receptionists also play their part.

Geothermal is a young, developing industry. Researchers in private and government institutions work on technology improvements. All of these people work in the geothermal industry to keep power turbines rolling and clean heat and electricity coming to you and me.

Adapted from the *Steam Press*, Spring 1992

It's Time For An Oil Change!

Renewable energy resources can play a major role in our quest for independence from foreign oil.

Recent events underscore, once again, the fact that we can no longer rely on imported oil. Some twenty years ago, when oil prices skyrocketed, service stations across America were besieged by gas lines, the sale of locking gas caps soared and gas rationing loomed as a real possibility. It seems that we did not learn our lesson from that experience. As that crisis eased, we went right back to the old ways, with no plans or energy programs for such future catastrophes. As a result, we became even more dependent on oil. Imported oil now accounts for approximately 50% of our current fuel needs, compared with less than 30% in 1985. And now we have another problem and an added financial burden — the astronomical costs of protecting these foreign oil resources.We know too that, compounding the problem, the burning of oil and other fossil fuels is doing irreparable damage to our environment. Carbon dioxide emissions, the "greenhouse" effect and global warming are now household words. How can we help reverse the damage and put the U.S. back on the road to energy independence? We must begin immediately an aggressive program to initiate more energy conservation programs and to develop our renewable energy sources. The true potential of geothermal, solar, wind and other alternative energy reserves within the U.S. is enormous. They are proven resources that, in many cases, cost substantially less than oil, coal and natural gas. But perhaps the biggest incentive for us to focus our energy on these renewable energy sources is the very future of our planet itself.

(Adapted from the *Steam Press*, Fall 1990)

Geothermal's HOT HISTORY

Early History

3500 years ago Mineral springs used by ancient Romans for bathing, cooking and heating. Hot springs also used by the Chinese, Japanese and later by native Americans.

2000 years ago Geothermal waters used to treat eye and skin diseases throughout the Mediterranean.

1000 years ago Yellow sulfur for salves, gunpowder, disinfectants, and other uses produced from geothermal salts.

1800's

1890 Production of boric acid for medicinal purposes from geothermal springs.

1891 First U.S. district heating from geothermal implemented in Boise, Idaho.

Early-Mid 1900's

1900 Geothermally-heated water provided to homes in Klamath Falls, Oregon.

1904 Electricity generated from Earth's natural steam, Larderello, Italy.

1930's Geothermal water now commonly used in the U.S., Iceland, Japan, New Zealand, the Soviet Union and other countries for spas, pools and greenhouses. First use in Iceland for heating of buildings.

1943 132 megawatts produced from geothermal fields in Larderello, Italy.

Late 1900's

1958 New Zealand successfully produced electricity from geothermal using a new method (flash).

1960 First commercial electricity generated from dry steam at The Geysers, California.

1966 First geothermal power plant built in Japan.

1969 France begins large district heating projects with geothermal waters.

1970 First electrical generation from geothermal in China. Exploration for geothermal resources begins in Greece and Guatemala.

1978 First Hot Dry Rock reservoir created and tested by the U.S. Department of Energy in New Mexico. Geothermal crop-drying plant built in Nevada.

1979 First electrical production from geothermal in Indonesia.

1980 World's largest geothermal generator (132 MW) built at The Geysers. Electric power from hot dry rock produced in New Mexico.

1981 Binary technology successfully used in the Imperial Valley, California. First electrical production from geothermal in state of Hawaii.

1982 Total U.S. installed geothermal capacity reaches 1000 MW.

1984 First electrical production from geothermal in Utah.

1985 U.S. installed geothermal capacity reaches 2000 MW. 2 MW electrical generation begins in Greece.

1989 First exploratory well to be sited directly over a body of magma by U.S. Department of Energy.

1990 Three U.S. geothermal projects win environmental awards. U.S. installed geothermal capacity reaches almost 3000 MW. New Zealand has about 300 MW of geothermal power plants. 700 MW are being produced in Mexico. 558 MW are being produced in the Philippines. Iceland has drilled, since about 1928, 110 wells for electrical production and 705 wells for direct use.

1991 Bonneville Power Administration selects three sites in the Pacific Northwest for demonstration geothermal projects.

1992 Nearly 6,000 MW of electricity being generated from geothermal in 21 countries.

1993 23 MW binary power plant completed at Steamboat Springs, Nevada. A 50 MW flash steam power plant completed at Los Azufres Geothermal Field in Michoacan, Mexico by Comision Federal de Electricidad (Mexico's state utility).

1994 Acceptance of the Environmental Impact Statement for the Newberry Pilot Project, allowing the first geothermal power plant in Oregon. Costa Rica becomes a geothermal country with the completion of a 50 MW flash steam power plant at Miravalles Geothermal Field.

Tomorrow

The amount of electricity being produced from hydrothermal resources will certainly continue to grow. Scientists from the U.S. Department of Energy are working hard to find ways to access and use the earth's heat at very deep levels — up to 10 miles! This research is focused on magma and hot dry rock.

By the year 2030, generation of electricity from geothermal sources is projected to grow to 10,600 MW. That's enough electricity to serve 10.5 million households.

The value of low temperature geothermal resources will continue to be researched and will be more widely used.

(Adapted from the *Steam Press*, Spring 1992)

HOT LUNCH

Let Mother Nature Do the Cooking!

Geothermal energy sizzles supper

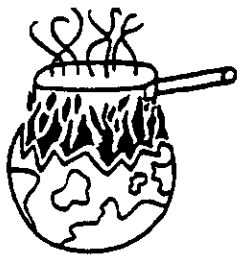
Adapted with permission from Reuters

When the villagers of Furnas (in the Azores) bury food in the ground around their local volcano, they know a piping hot meal will be ready in a few hours.

"This is what I call down-to-earth cooking," says Fernando Moniz Cabral, as he and another man heave huge pots of cozido, a spicy stew of chicken, sausages, pork and vegetables, from holes in the earth.

Faces red from the effort and heat, they emerge between billows of steam and pools boiling away in the green landscape of tropical flowers, palm trees and lagoons.

For centuries these villagers on the Azores island of Sao Miguel in the mid-Atlantic have harnessed volcanic (geothermal)



energy to bake anything from cod to cabbage. The volcanic island, like others in the nine-island Portuguese archipelago, lies on a thin layer of the earth's crust.

During weekends, the site is filled with picnicking families who drop sacks of meat, yams, potatoes and even cornbread into the three-foot deep holes for a couple of hours while they swim at the nearby crater lake. Barefoot boys sitting by the roadside sell husks of "cooked" sweet corn.

With a heat of about 200° Fahrenheit, connoisseurs recommend burying fish for about two hours and meat for up to five. Food is wrapped in paper or cabbage leaves, pots tightly sealed and earth put over the holes to trap the vapor.

Signs spell out the rules: "Cooking corn is not permitted here." "Do not wash clothes." "Using detergent is not allowed." Down the road, tourists stay at a nearby 19th century spa where spring water enriched with minerals pours from rocks laced with purple flowers. And, just a few miles away, engineers are trying to tap the volcanic heat to generate electricity and end dependency on imported fuel.

(Adapted from the *Steam Press*, Spring 1992)

Drawing by Nikki Nemzer

Just Add Water!

Everywhere in the world there's lots of hot rock very deep down in the Earth's crust. Most of it is more than ten miles deep, but in some places it's close enough to the surface for water to trickle down, get all steamed up and create hot underground reservoirs and geothermal systems with hot springs, fumaroles and geysers. We take heat from this hot wet (hydrothermal) rock to make electricity and to heat all sorts of things.

But most of the hot rock doesn't have water trickling into it. Most is Hot *Dry* Rock (nickname HDR), the technical name for this kind of geothermal resource. Scientists from the U.S. Department of Energy - along with researchers from Japan, England, France and Germany - have found a way to *add* the water. In areas where the hot dry rock isn't too deep (up to three and a half miles), engineers drill two parallel wells about 10 inches in diameter. Then they pump water, under pressure, through one of the wells. This pressurized water fractures the rock and opens up natural cracks in the rock at the base of the two wells to connect them. After the rock fractures have been opened, the engineers run cool water down one of the wells to the hot dry rock.

You can guess what happens next! The cool water runs through the large cracks in the hot dry rock and - *voila!* The water gets hot! *Muy caliente! Molto caldo! Totemo atsui!* The Hot Dry Rock system creates (with a little help) its own hydrothermal resource!

Then, of course, the hot water (up to 300 degrees C) comes up the second well, providing the precious clean energy that will be needed to turn the turbines in the power plant above. One of the best things about Hot Dry Rock technology is that when the heated water has done its job at the surface, it is sent right back down again through the well to the hot dry rock underground. And around and around it goes!

In future years, drilling technology will improve, allowing us to drill deeper and deeper, making geothermal energy from Hot Dry Rock potentially available everywhere!

In geothermal energy circles, being "all wet" is a real advantage.

(Adapted from the *Steam Press*, Spring 1993)

CURRENT TOPIC: MIGHTY MAGMA

The United States Department of Energy has some exciting things happening at Mammoth Lakes, California, where long-term research is underway to see if we can use magma to produce electricity: magma's heat might be able to be conveyed through fluid in pipes to make steam to power turbine-generators. Magma is a huge potential resource. Would you believe that the amount of energy that may be available from magma is greater than all oil, coal and gas resources put together? The big question is, "Is it available at shallow enough depths to make it useful to mankind?" Researchers and scientists from the Department of Energy think the answer is "yes." That would be a lot of electricity! Experimental drilling, planned to be four miles deep, has begun in Long Valley Caldera, which was formed over 700,000 years ago from a volcanic eruption over 1,000 times more powerful than the recent Mt. St. Helens eruption! It is a good place for magma research because it is still very geologically active. Maybe someday electricity will be produced from mighty magma! How clean our air would be!

(Adapted from the *Steam Press*, Fall 1990)

HOT WATER

Reno Hotel Has Its Own Geothermal System For Heat

The Peppermill Hotel and Casino has had its very own low temperature geothermal well right in its backyard for over thirty years. The geothermal resource is used to directly heat water for bathing, laundry and heating. The hotel has over 600 rooms, so that is a lot of hot water. In fact, they plan to sell their extra hot water to the car wash across the road and to other nearby businesses. The Peppermill Hotel's well is a "double jackpot winner" — free hot water and good for the environment too!

(Reprinted from the *Steam Press*, Fall 1990)

THE HOT SEAT

Geothermal Energy Questions & Answers

Q. If geothermal is so great, why don't we use it to make all our electricity?

A. We would if we could. Not all geothermal resources are hot enough to produce electricity. Also, some of the "hot enough" resources aren't accessible for use with present-day technology. (The U.S. Department of Energy is doing research to improve technology so we will be able to use more of our geothermal resources.) And "low" temperature geothermal resources are also available for many uses which help us cut down electricity use.

Q. If there is geothermal heat in the earth, why don't my feet get hot?

A. They would if you put them in a hot spring, but in most places, layers of rock, sand and soil protect us from the heat deep inside the earth. Geothermal is everywhere underground, but at a depth safe to our feet.

Q. Will we ever run out of geothermal energy?

A. No. Future generations will always have geothermal energy. Hydrothermal reservoirs contain both water (hydro) and heat (thermal). The heat is always being generated deep in the earth. The water is replenished by rainfall and by returning the used water back into the reservoir.

Q. I have heard that geothermal plants emit carbon dioxide and sulfur gases that contribute to acid rain and global warming. Is it true?

A. It is true that geothermal steam contains sulfur as hydrogen sulfide (H_2S), but the steam is treated to remove almost all of the H_2S. Carbon dioxide (CO_2) is also in geothermal steam, but in comparatively small amounts. A power plant that burns coal to make electricity produces 1700 times as much CO_2 for the same amount of electricity as a geothermal plant. Geothermal energy doesn't flood valleys, cause air pollution, make miners sick or leave radioactive waste. It is a very clean energy technology.

Q. Mexico has a lot of volcanic and earthquake activity. Are they doing anything with geothermal energy?

A. Are they ever! Mexico has more than 130 known geothermal fields, a number of which are already producing geothermal electricity. One of the areas explored, the Cerro Prieto field, is currently producing over 600 MW (much of which is being sold to a utility in the U.S.) and may be able to produce up to 1 million kilowatts of power! Mexico also has many geothermal hot springs which attract thousands of tourists each year.

Q. What else is new in the geothermal industry?

A. Glad you asked! Some geothermal engineers have been inventing portable geothermal power plants! These pre-packaged modular, mobile units have been set up in places which ordinarily wouldn't have electric power, such as the one found in Dieng, Java.

(Adapted from the *Steam Press*, Spring 1992)

HOT STUFF

TRUE or FALSE

____ 1. Geothermal energy is available practically everywhere, if you just dig down far enough.

____ 2. The first United States geothermal electricity power plant was built in Bakersfield, CA.

____ 3. Greenhouses cannot use geothermal resources.

____ 4. Bathing is a common use of geothermal resources.

____ 5. Islanders on Sao Miguel use geothermal heat for cooking.

____ 6. Use of magma's heat as a geothermal resource has never been explored.

____ 7. Mexico has many known geothermal fields.

MATCHING

___ 1. Coal, oil, natural gas

___ 2. Visible features of geothermal energy

___ 3. A well fitted with a pipe used to carry underground steam to electrical turbines

___ 4. Molten rock

___ 5. Rock heated by magma that is close to the earth's surface

___ 6. A device that turns when steam pushes its blades to generate electricity

___ 7. Stew cooked by geothermal heat in the Azores

A. Magma
B. Fossil fuels
C. Geothermal production well
D. Steam turbine
E. Cozido
F. Volcanoes, hot springs, geysers, and fumaroles
G. Hot Rock

WORD SCRAMBLE

1. RAGMELHOTE

_____

2. WEARBEELN YNREEG

_____

3. LOGOITEGS

_____

4. HSIF ERMARFS

_____

5. CLEITECYRIT

_____

6. LAGBOL GRINMAW

_____

7. REGOFIN LOI

_____

FOR THE TEACHER

1. Social Studies/Language Arts Activity: Suggestions using the articles from this section:

a. Have students pick an article of interest and do further research on the subject.

b. Ask a group of students to present the information found in the Scrapbook in the form of a TV news broadcast for the rest of the class.

c. Have students make posters "advertising" information from articles in the Scrapbook.

2. Social Studies Activity: Suggestion for the geothermal time line (Hot History): connect the geothermal history facts with a general historical timeline. Have students make their own timelines, putting in geothermal information and adding in other historical events. Pictures can be added to illustrate key facts or interesting details.

3. Activity Page: "Hot Stuff" Answers:

True or False:
1. T 2. F 3. F 4. T 5. T 6. F 7. T

Word Scramble:
1. geothermal 2. renewable energy 3. geologist
4. fish farmers 5. electricity 6. global warming
7. foreign oil

Matching: 1. B 2. F 3. C 4. A 5. G 6. D 7. E